

ERG\_LEAD\_45.pie

Figure 7-21. Side-view of a Typical Rotary Reverbertory Furnace

Source: Reference 236.

A rotary furnace consists of a refractory-lined steel drum mounted on rollers. Variable-speed motors are used to rotate the drum. An oxygen-enriched natural gas or fuel oil jet at one end of the furnace heats the charge material and the refractory lining of the drum. The connection to the flue is located at the same end as the jet. A sliding door at the end of the furnace opposite from the jet allows charging of material to the furnace. Charge materials are typically placed in the furnace using a retractable conveyor or charge bucket, although other methods are possible.

Lead-bearing raw materials charged to rotary furnaces include broken battery components, flue dust, and drosses. Rotary furnaces can use the same lead-bearing raw materials as reverberatory furnaces, but they produce slag that is relatively free of lead, less than 2 percent. As a result, a blast furnace is not needed for recovering lead from the slag, which can be disposed of as a nonhazardous waste.

Fluxing agents for rotary furnaces may include iron, silica, soda ash, limestone, and coke. The fluxing agents are added to promote the conversion of lead compounds to lead metal. Coke is used as a reducing agent rather than as a primary fuel. A typical charge may consist of 12 tons (11 Mg) of wet battery scrap, 0.8 tons (0.7 Mg) of soda ash, 0.6 tons (0.5 Mg) of coke, and 0.6 tons (0.5 Mg) of iron. This charge will yield approximately 9 tons (8 Mg) of lead product.<sup>236</sup>

The lead produced by rotary furnaces is a semi-soft lead with an antimony content somewhere between that of lead from reverberatory and blast furnaces. Lead and slag are tapped from the furnace at the conclusion of the smelting cycle. Each batch takes 5 to 12 hours to process, depending on the size of the furnace. Like reverberatory furnaces, rotary furnaces are operated at a slight negative pressure.

## Electric Furnaces

An electric furnace consists of a large, steel, kettle-shaped container that is refractory-lined (Figure 7-22).<sup>236</sup> A cathode extends downward into the container and an anode is located in the bottom of the container. Second-run reverberatory furnace slag is charged into the top of the furnace. Lead and slag are tapped from the bottom and side of the furnace, respectively. A fume hood covering the top of the furnace is vented to a control device.

In an electric furnace, electric current flows from the cathode to the anode through the scrap charge. The electrical resistance of the charge causes the charge to heat up and become molten. There is no combustion process involved in an electric furnace.

There is only one electric furnace in operation in the U.S. secondary lead industry. It is used to process second-run reverberatory furnace slag, and it fulfills the same role as a blast furnace used in conjunction with a reverberatory furnace. However, the electric furnace has two advantages over a blast furnace. First, because there are no combustion gases, ventilation requirements are much lower than for blast or reverberatory furnaces, and the potential for formation of organics is greatly reduced. Second, the electric furnace is extremely reducing, and produces a glass-like, nearly lead-free slag that is nonhazardous.

### 7.6.2 Benzene Emissions From Secondary Lead Smelters

Process emissions (i.e., those emitted from the smelting furnace's main exhaust) contain metals, organics (including benzene), HCl, and Cl<sub>2</sub>. Process emissions also contain other pollutants, including PM, VOC, CO, and SO<sub>2</sub>.

Blast furnaces are substantially greater sources of benzene emissions than reverberatory or rotary furnaces. Low exhaust temperatures from the charge column (about 800°F [430°C]) result in the formation of PICs from the organic material in the feed material.

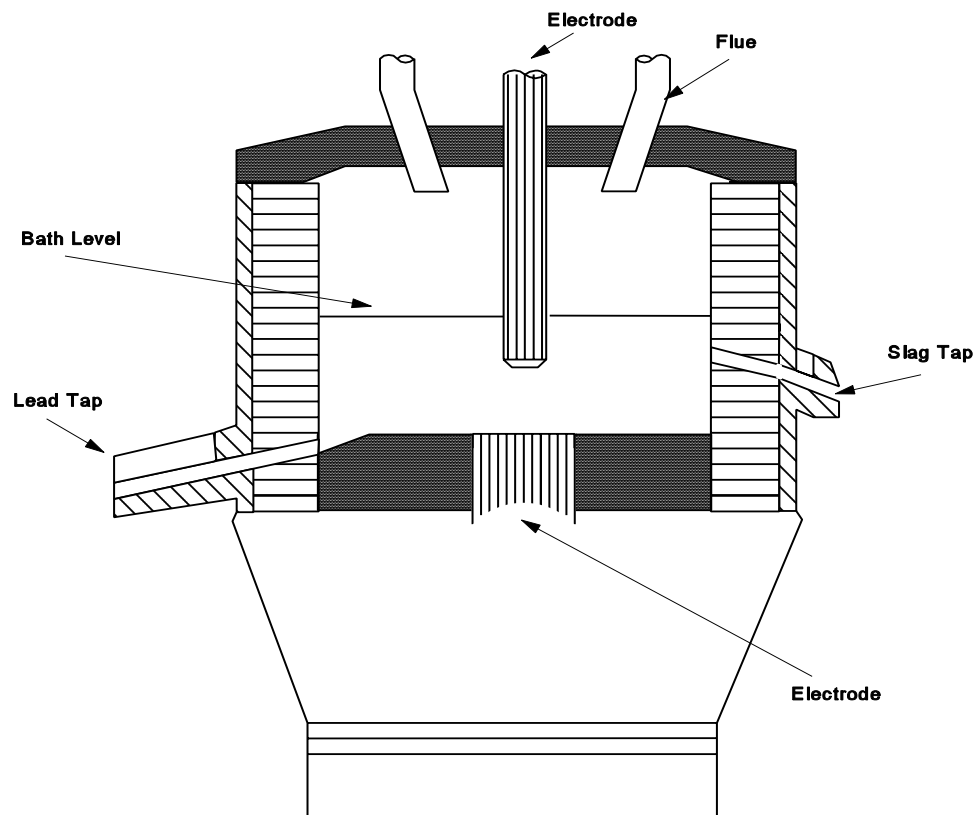


Figure 7-22. Cross-sectional View of an Electric Furnace for Processing Slag

Source: Reference 236.

Uncontrolled THC emissions (which correlate closely with organic pollutant emissions) from a typical 55,000-tons/yr (50,000 Mg/yr) blast furnace are about 309 tons/yr (280 Mg/yr).<sup>236</sup>

Controlled blast furnace benzene emissions are dependent on the add-on controls that are used, which may be anywhere from 80 to 99 percent effective at reducing THC emissions. Rotary and reverberatory furnaces have much higher exhaust temperatures than blast furnaces, about 1,800 to 2,200°F (980 to 1,200°C), and much lower THC emissions because of more complete combustion. Total hydrocarbon emissions from a typical rotary furnace (16,500 tons/yr [15,000 Mg/yr] capacity) are about 38 tons/yr (34 Mg/yr). The majority of these emissions occur during furnace charging, when the furnace's burner is cut back and the temperature is reduced. Emissions drop off sharply when charging is completed and the furnace is brought to normal operating temperature.<sup>236</sup> Benzene emissions from reverberatory furnaces are even lower than those from rotary furnaces because reverberatory furnaces are operated continuously rather than on a batch basis.

Three test reports from three secondary lead smelters were used to develop benzene emission factors.<sup>237-240</sup> All testing was conducted in support of the EPA's Secondary Lead National Emission Standards for Hazardous Air Pollutants (NESHAP) program. The three facilities tested represent the following process configurations: a rotary smelting furnace equipped with a baghouse and SO<sub>2</sub> scrubber; a blast furnace equipped with an afterburner, baghouse, and SO<sub>2</sub> scrubber; and a reverberatory and blast furnace with exhaust from each furnace combined prior to a single afterburner, baghouse, and SO<sub>2</sub> scrubber.

Uncontrolled VOC emissions were measured at all three facilities using VOST.<sup>241</sup> Nineteen VOC, including benzene, were detected by the VOST. Benzene emissions were measured at the blast furnace outlet (before the afterburner) at two facilities, and at the rotary furnace outlet at one facility. Total hydrocarbon emissions were measured at both the blast furnace and rotary furnace outlets and at the afterburner outlets following the blast furnaces. Emission factors for benzene are shown in Table 7-11.<sup>237-240</sup> Although benzene emissions were not measured after the control device, controlled emission factors were

TABLE 7-11. SUMMARY OF BENZENE EMISSION FACTORS FOR SECONDARY LEAD SMELTING

| SCC         | Emission Source             | Control Device | Emission Factor<br>lb/ton (kg/Mg) <sup>a</sup>                  | Emission<br>Factor Rating | Reference     |
|-------------|-----------------------------|----------------|---|---------------------------|---------------|
| 3-04-004-03 | Blast furnace               | Uncontrolled   | $4.08 \times 10^{-1}$<br>( $2.04 \times 10^{-1}$ )              | D                         | 237, 238, 240 |
|             |                             | Afterburner    | $2.47 \times 10^{-2}$ <sup>b</sup><br>( $1.23 \times 10^{-2}$ ) | D                         | 237, 238, 240 |
| 3-04-004-04 | Rotary Furnace <sup>c</sup> | Uncontrolled   | $1.66 \times 10^{-1}$<br>( $8.30 \times 10^{-2}$ )              | D                         | 239           |

<sup>a</sup> Emission factors are in lb (kg) of benzene emitted per ton (Mg) of lead smelted.

<sup>b</sup> Average emission factor from two facility test reports.

<sup>c</sup> Batch-operated furnace with two charging episodes per batch and an average of 18 hours per batch (during the emissions test).

estimated using the THC control efficiency for the given process configuration. These estimates assume that the control efficiency for benzene was equal to the control efficiency for THC.

### 7.6.3 Control Technologies for Secondary Lead Smelters

Controls used to reduce organic emissions from smelting furnaces in the secondary lead smelting industry include afterburners on blast furnaces and combined blast and reverberatory exhausts. Reverberatory and rotary furnaces have minimal benzene emissions because of high exhaust temperatures and turbulence, which promote complete combustion of organics. No controls for THC are necessary for these process configurations.<sup>236</sup>

Benzene emissions from blast furnaces are dependent on the type of add-on control used. An afterburner operated at 1,300°F (700°C) achieves about 84 percent destruction efficiency of THC.<sup>236</sup> Facilities with blast and reverberatory furnaces usually combine the exhaust streams and vent the combined stream to an afterburner. The higher operating temperature of the reverberatory furnace reduces the fuel needs of the afterburner so that the afterburner is essentially “idling.” Any temperature increase measured across the afterburner is due to the heating value of organic compounds in the blast furnace exhaust. A combined reverberatory and blast furnace exhaust stream ducted to an afterburner with an exit temperature of 1,700°F (930°C) can achieve 99-percent destruction efficiency for THC.<sup>236</sup>

Additional controls used by secondary lead smelters include baghouses for particulate and metal control, hooding and ventilation to a baghouse for process fugitives, and scrubbers for HCl and SO<sub>2</sub> control.<sup>236</sup>

## 7.7 IRON AND STEEL FOUNDRIES

Iron and steel foundries can be defined as those that produce gray, white, ductile, or malleable iron and steel castings. Cast iron and steels are both solid solutions of

iron, carbon, and various alloying materials. Although there are many types of each, the iron and steel families can be distinguished by their carbon content. Cast irons typically contain 2 percent carbon or greater; cast steels usually contain less than 2 percent carbon.<sup>242</sup>

Iron castings are used in almost all types of equipment, including motor vehicles, farm machinery, construction machinery, petroleum industry equipment, electrical motors, and iron and steel industry equipment. Steel castings are classified on the basis of their composition and heat treatment, which determine their end use. Steel casting classifications include carbon, low-alloy, general-purpose-structural, heat-resistant, corrosion-resistant, and wear-resistant. They are used in motor vehicles, railroad equipment, construction machinery, aircraft, agricultural equipment, ore refining machinery, and chemical manufacturing equipment.<sup>242</sup>

Based on a survey conducted by EPA in support of the iron and steel foundry MACT standard development, there were 756 iron and steel foundries in the United States in 1992.<sup>243</sup> Foundry locations can be correlated with areas of heavy industry and manufacturing and, in general, with the iron and steel production industry (Ohio, Pennsylvania, and Indiana).

Additional information on iron and steel foundries and their locations may be obtained from the following trade associations:

- American Foundrymen's Society, Des Plaines, Illinois;
- National Foundry Association, Des Plaines, Illinois;
- Ductile Iron Society, Mountainside, New Jersey;
- Iron Casting Society, Warrendale, Pennsylvania; and
- Steel Founders' Society of America, Des Plaines, Illinois.



### 7.7.1 Process Description for Iron and Steel Foundries

The following four basic operations are performed in all iron and steel foundries:

- Storage and handling of raw materials;
- Melting of the raw materials;
- Transfer of the hot molten metal into molds; and
- Preparation of the molds to hold the molten metal.

Other processes present in most, but not all, foundries include:

- Sand preparation and handling;
- Mold cooling and shakeout;
- Casting cleaning, heat treating, and finishing;
- Coremaking; and
- Pattern making.

A generic process flow diagram for iron and steel foundries is given in Figure 7-23.<sup>242</sup>

Figure 7-24 depicts the emission points in a typical iron foundry.<sup>244</sup>

Iron and steel castings are produced in a foundry by injecting or pouring molten metal into cavities of a mold made of sand, metal, or ceramic material. Input metal is melted by the use of a cupola, an electric arc furnace, or an induction furnace. About 70 percent of all iron castings are produced using cupolas, with lesser amounts produced in electric arc and induction furnaces. However, the use of electric arc furnaces in iron foundries is increasing. Steel foundries rely almost exclusively on electric arc or induction furnaces for melting purposes. With either type of foundry, when the poured metal has solidified, the molds are separated and the castings removed from the mold flasks on a casting shakeout unit. Abrasive

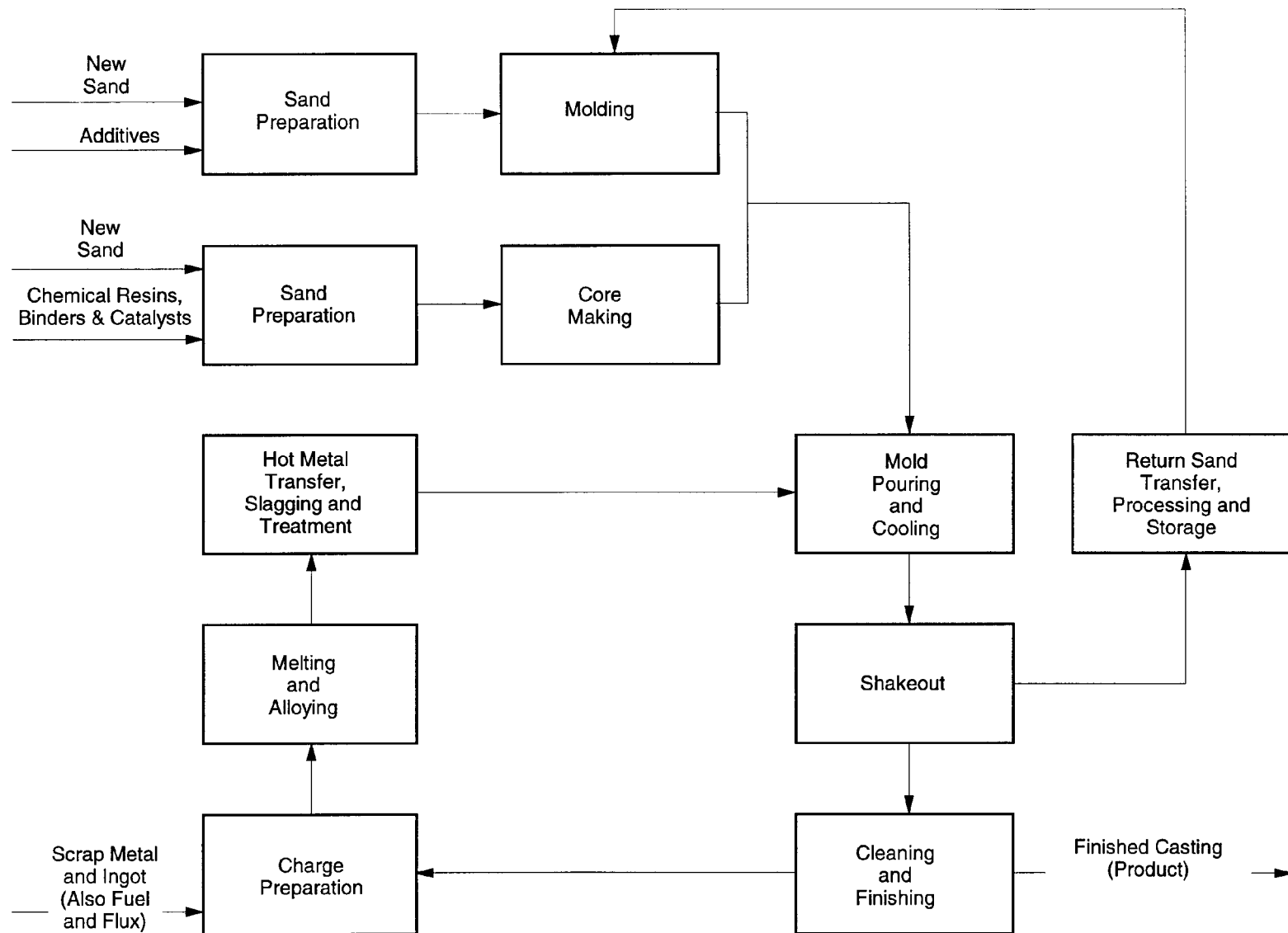


Figure 7-23. Process Flow Diagram for a Typical Sand-Cast Iron and Steel Foundry

Source: Reference 242.